

Measuring Kernel Quality of Midwest Hazelnuts

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Challenge: Selectively breeding hazelnuts is a slow, labor-intensive process

Plants take ~8 years to fully mature



We can only select for traits we can measure

- Plant architecture
- Disease resistance
- Yield
- Kernel size & shape
- % kernel
- Flavor
- **Nutrient content**

Lab analysis is slow – 16 samples every 4 days

% Moisture

Grind & freeze dry



Day 1



Days 1-4

% Oil

Oil extraction



Days 2-3

Fatty Acid Profile

NMR analysis



Day 4

% Protein

Combustion analysis

We could be working slower, but is there an even better approach?

Standard Analytical Methods

Oil extraction (8-24 h)

- Specialized glassware + heating
- 1 sample at a time
- **101 days** for 100 samples

Fatty acid profile (GC-MS, HPLC)

- Extra sample prep required
- 15-30 min per sample
- **25-50 hours** for 100 samples

High Efficiency Methods

Oil extraction (24 h)

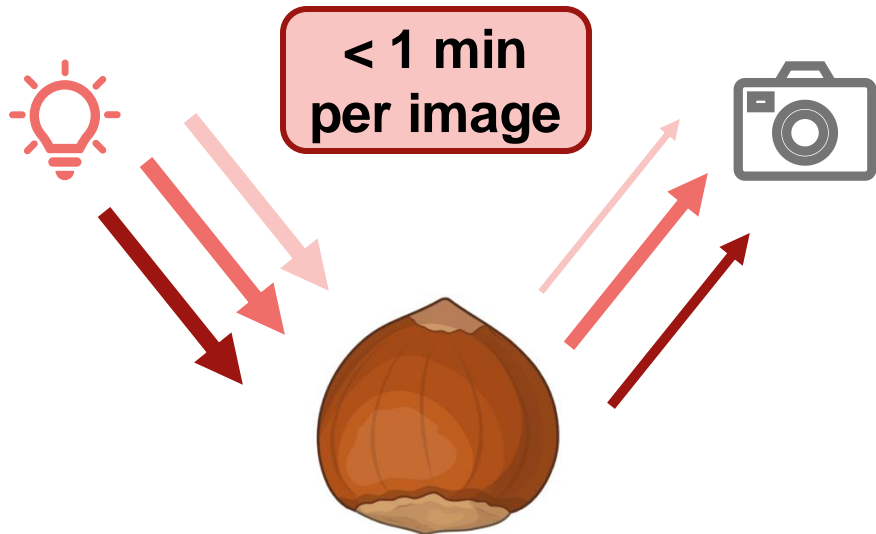
- Standard sample vials, no heat
- 16 samples in a batch
- **8 days** for 100 samples

Fatty acid profile (NMR)

- Minimal sample prep
- < 5 min per sample
- **7.5 hours** for 100 samples

Hypothesis: We can use near-infrared (NIR) imaging to predict nutritional traits in hazelnuts

NIR Imaging



Lab Analysis

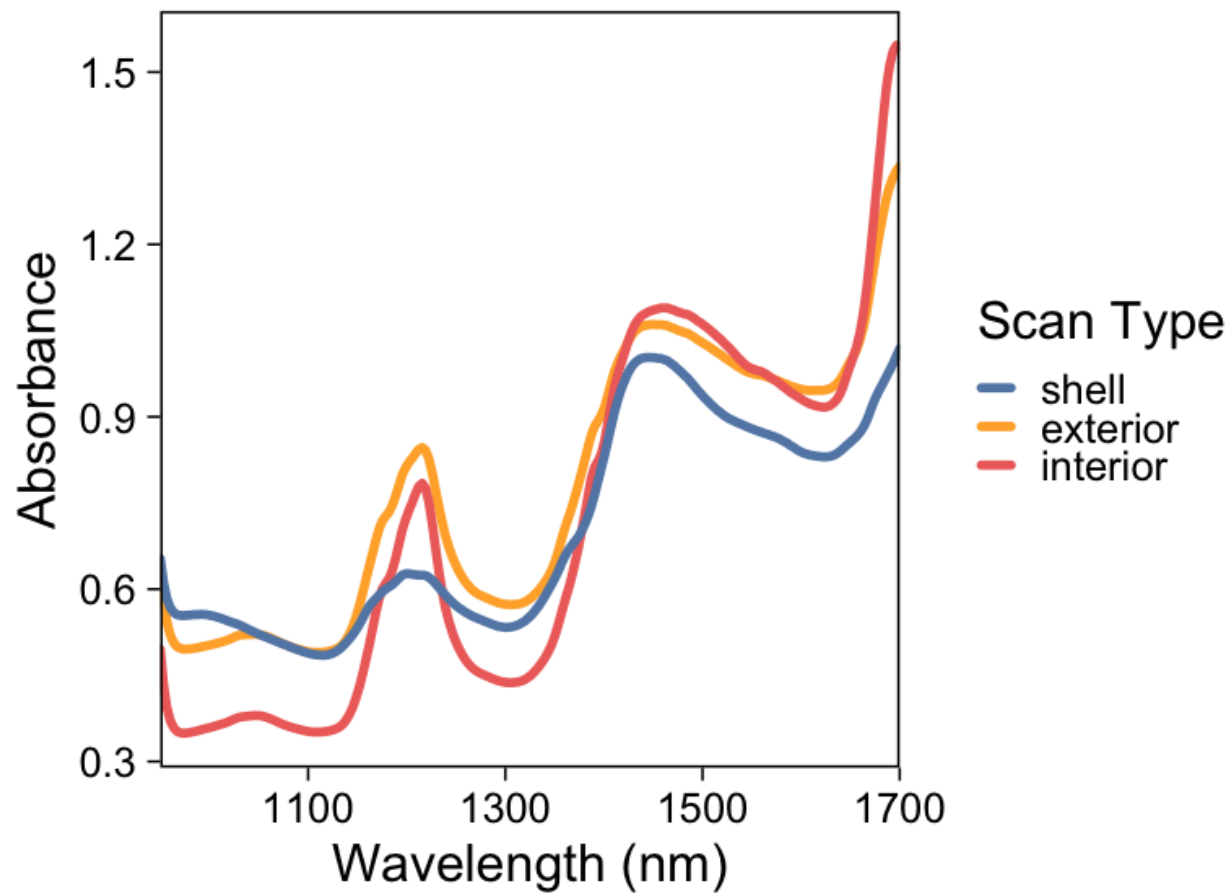
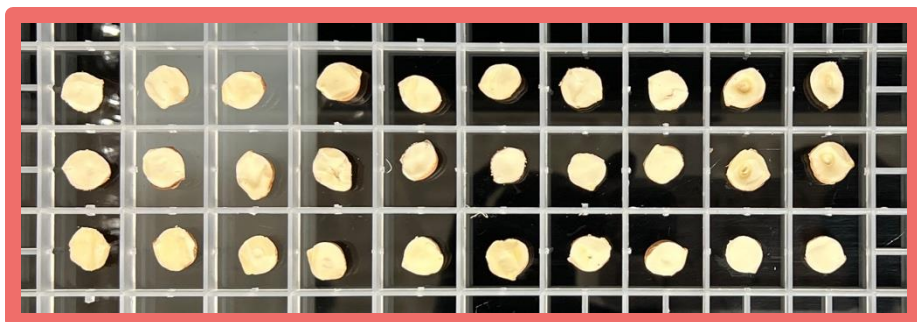


Total moisture
Total protein

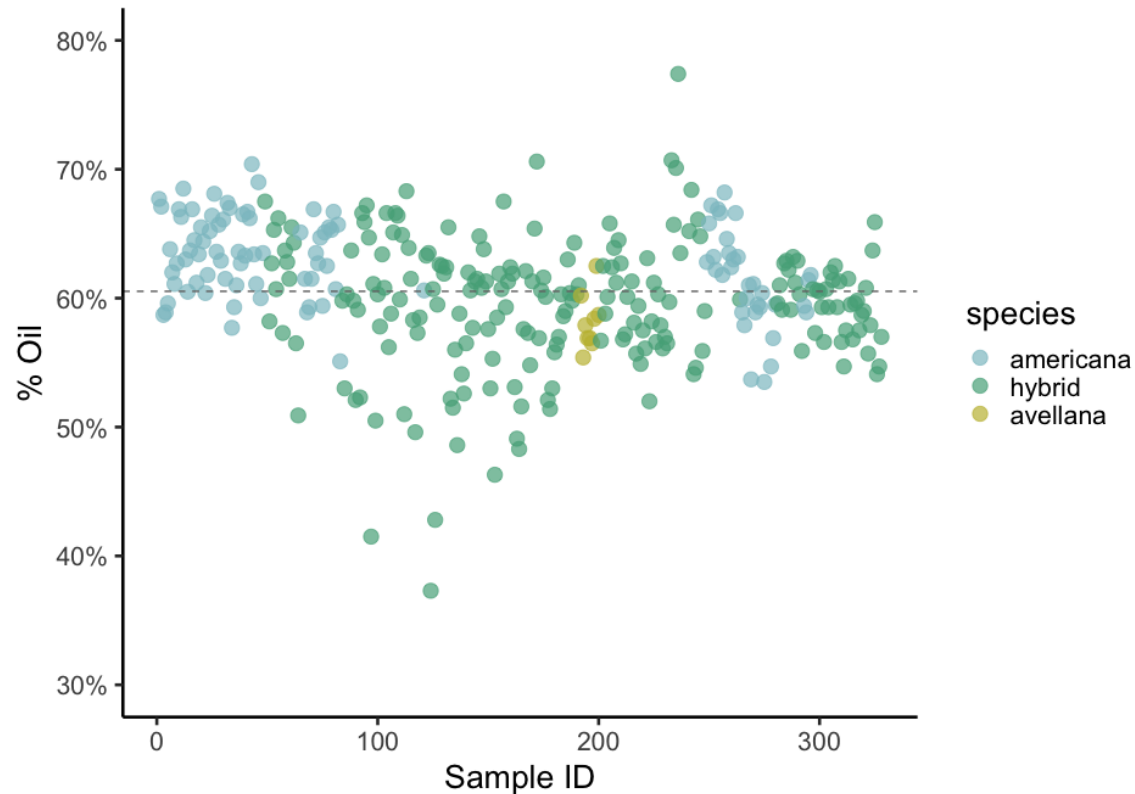
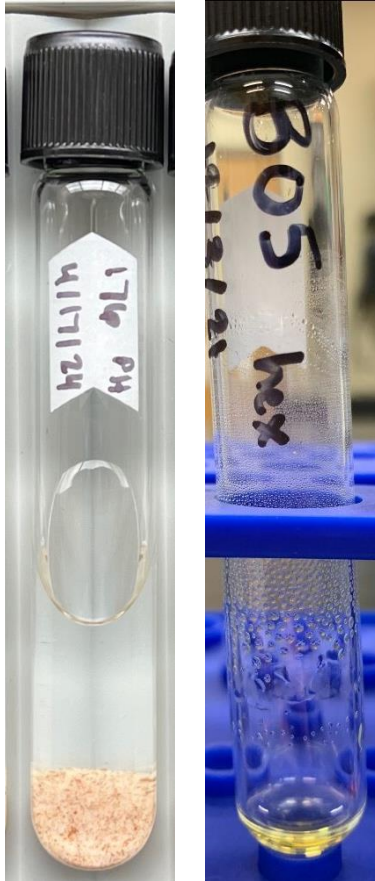
Total oil
Fatty acids

Build Predictive Model

Step 1: Collect near-infrared (NIR) scans of hazelnut samples from many different plants



Step 2: Collect lab measurements on those same hazelnut samples



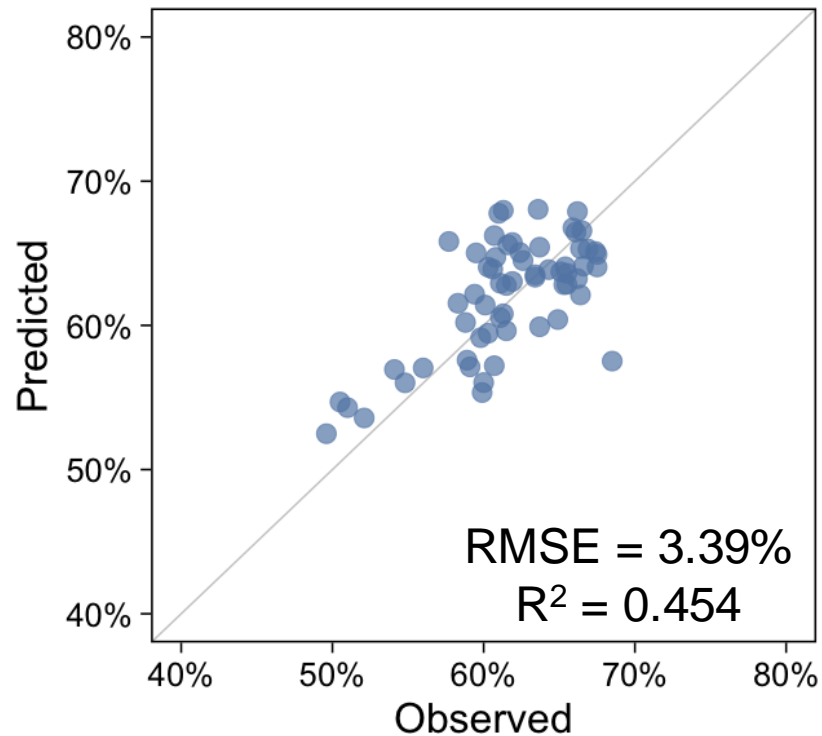
Current Traits

- Moisture
- Protein
- Oil
- Fatty acid profile
 - Oleic
 - Linoleic
 - Saturated

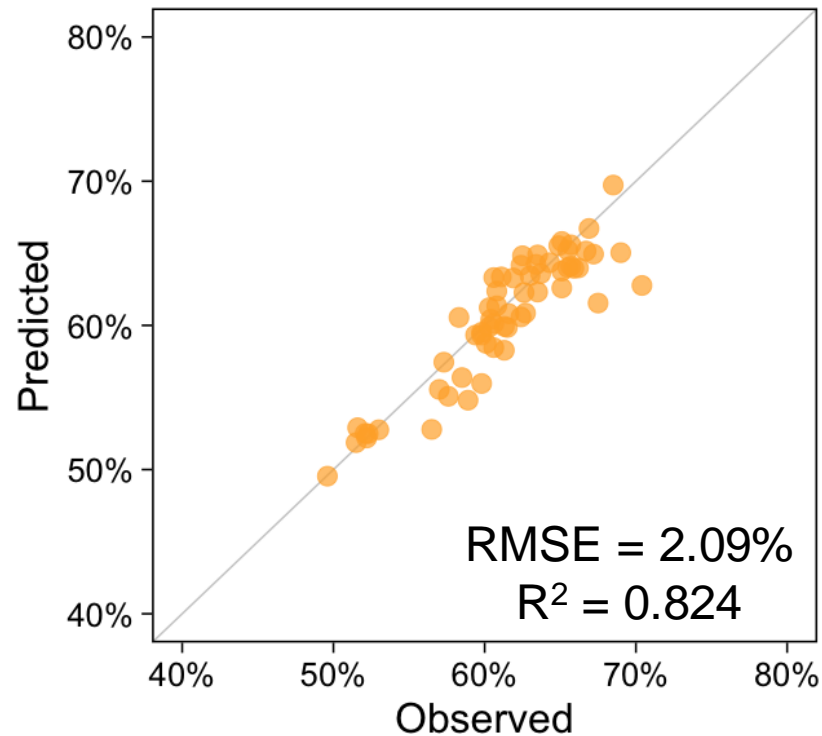
Step 3: Use NIR scans and lab data to build a model that predicts nutritional content for new samples



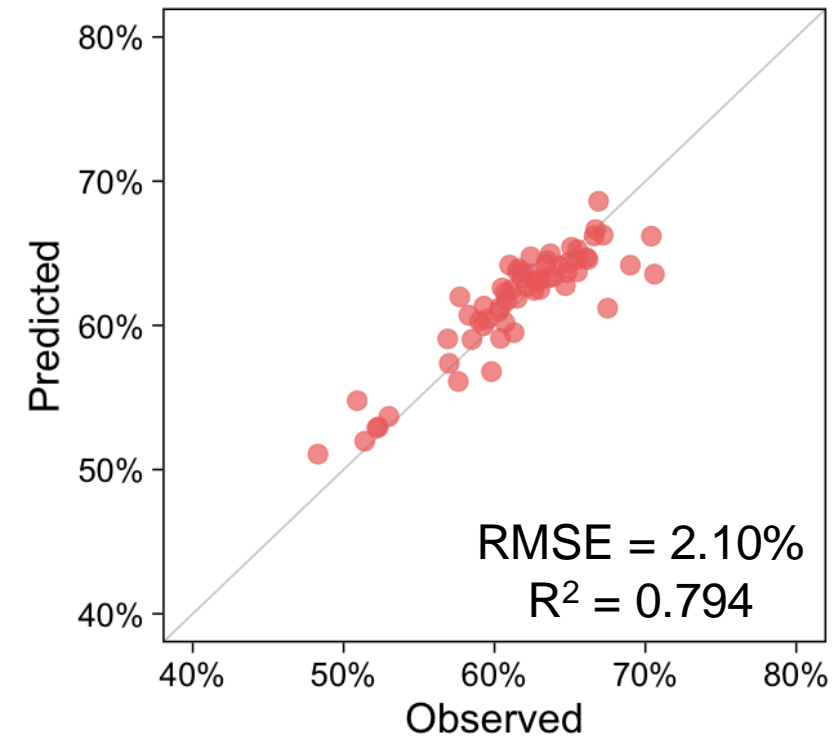
% Oil Predicted - Shell



% Oil Predicted - Exterior

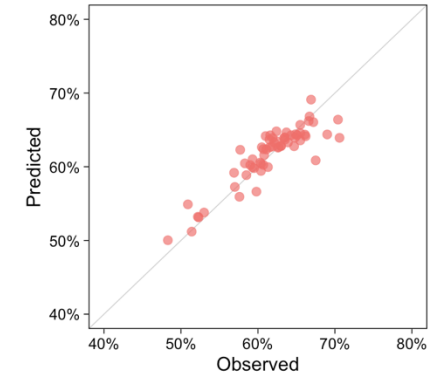
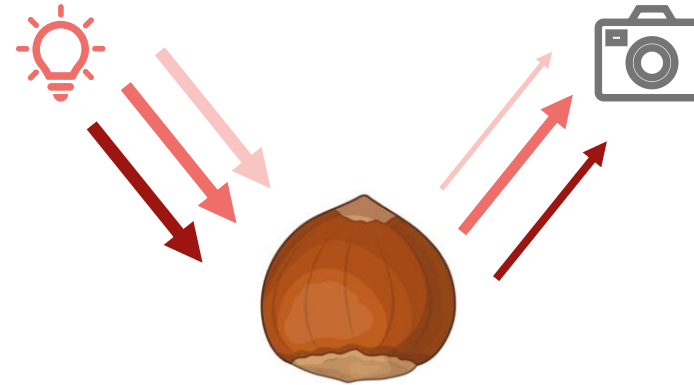


% Oil Predicted - Interior



NIR imaging could accelerate selection for high quality kernels in hazelnut breeding programs

- Next steps:
 - Refine NIR models with additional samples
 - Scan full hazelnut breeding populations to select top parent candidates
 - Develop complementary predictive models using genomic sequence data



Over 300 hazelnut samples have been analyzed so far

113 hybrid plants from 12 genotypes

50 from Madison, WI
12 from Spring Green, WI
16 from St. Paul, MN
35 from Rosemount, MN

208 total samples

69 *C. americana* plants

16 from Stoughton, WI
53 from Barneveld, WI

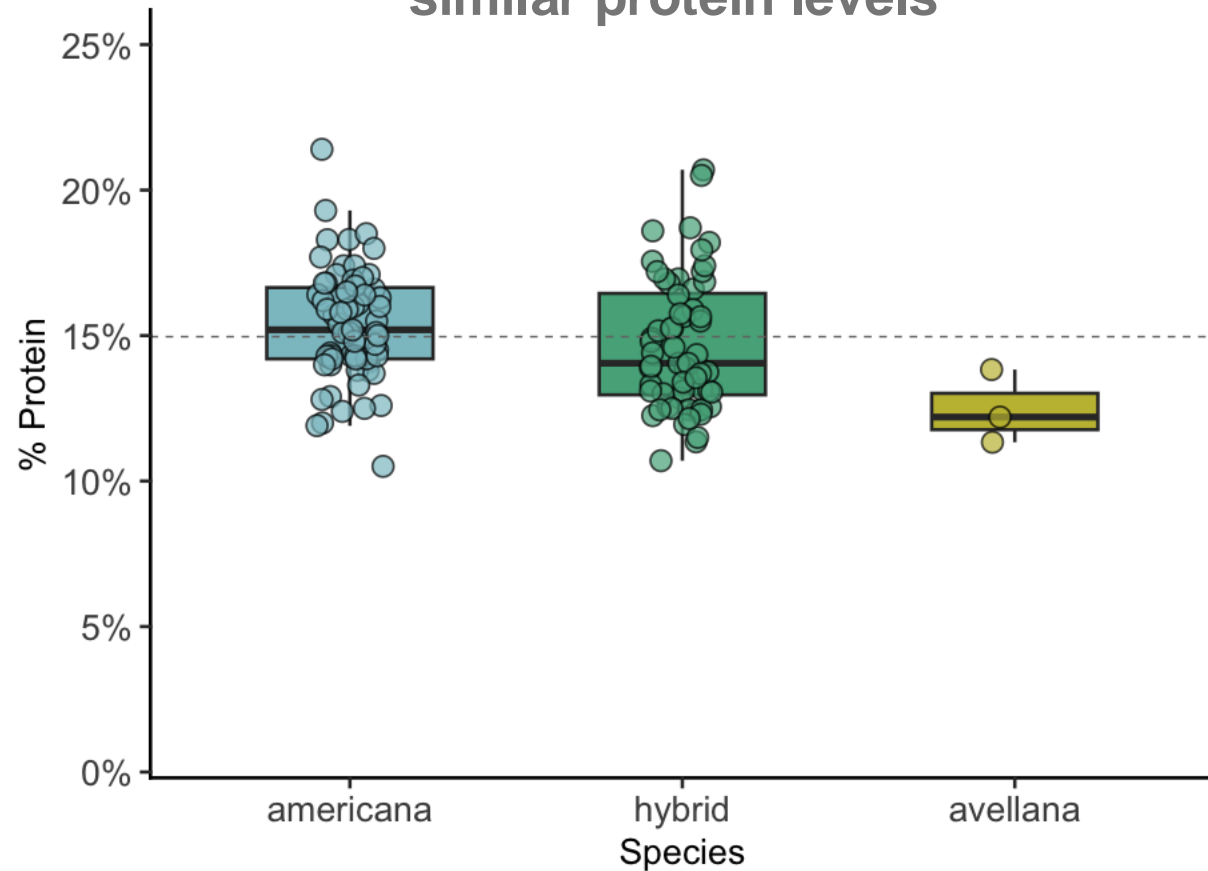
100 total samples

15 additional samples

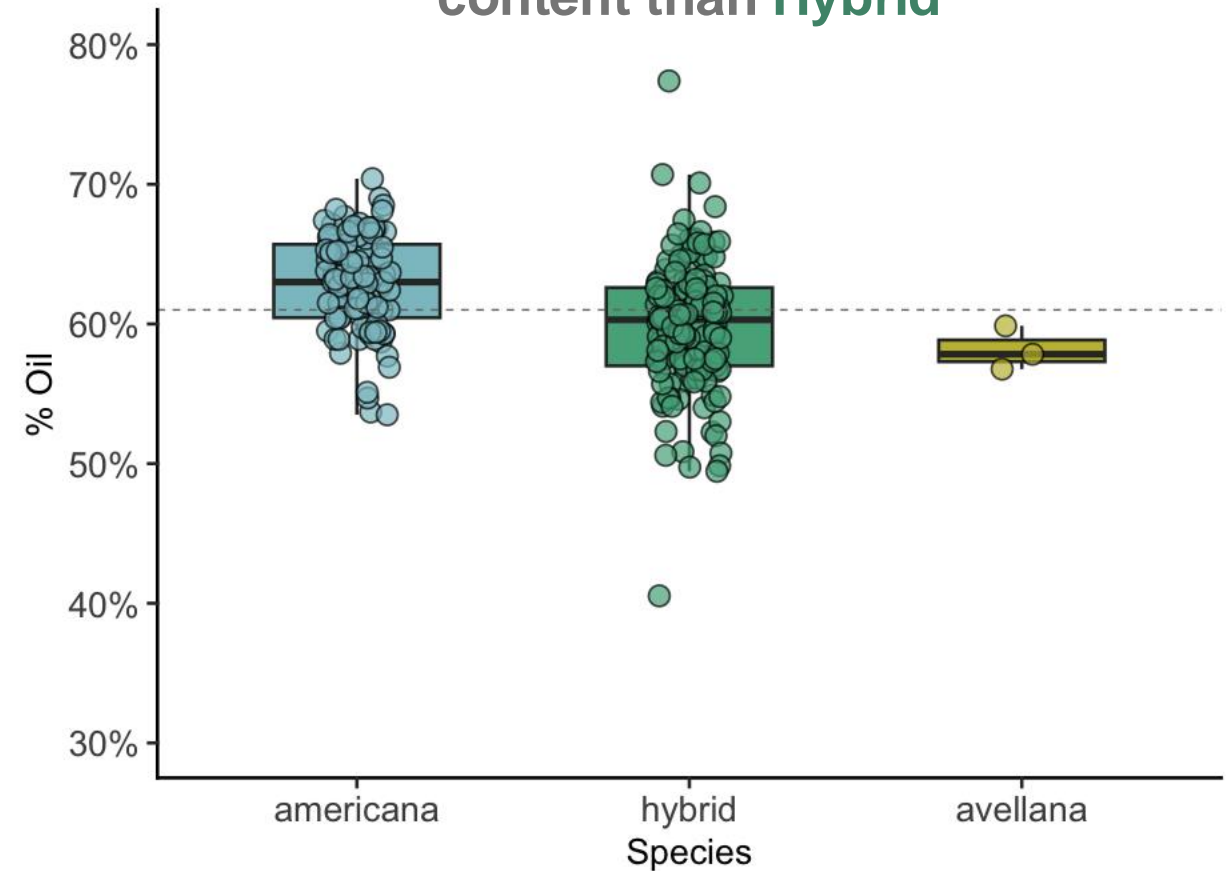
Nitka, Jefferson, Yamhill,
York, OSU Half-Sib

Protein and oil content vary widely across plants

Americana & Hybrid have similar protein levels



Americana has higher oil content than **Hybrid**

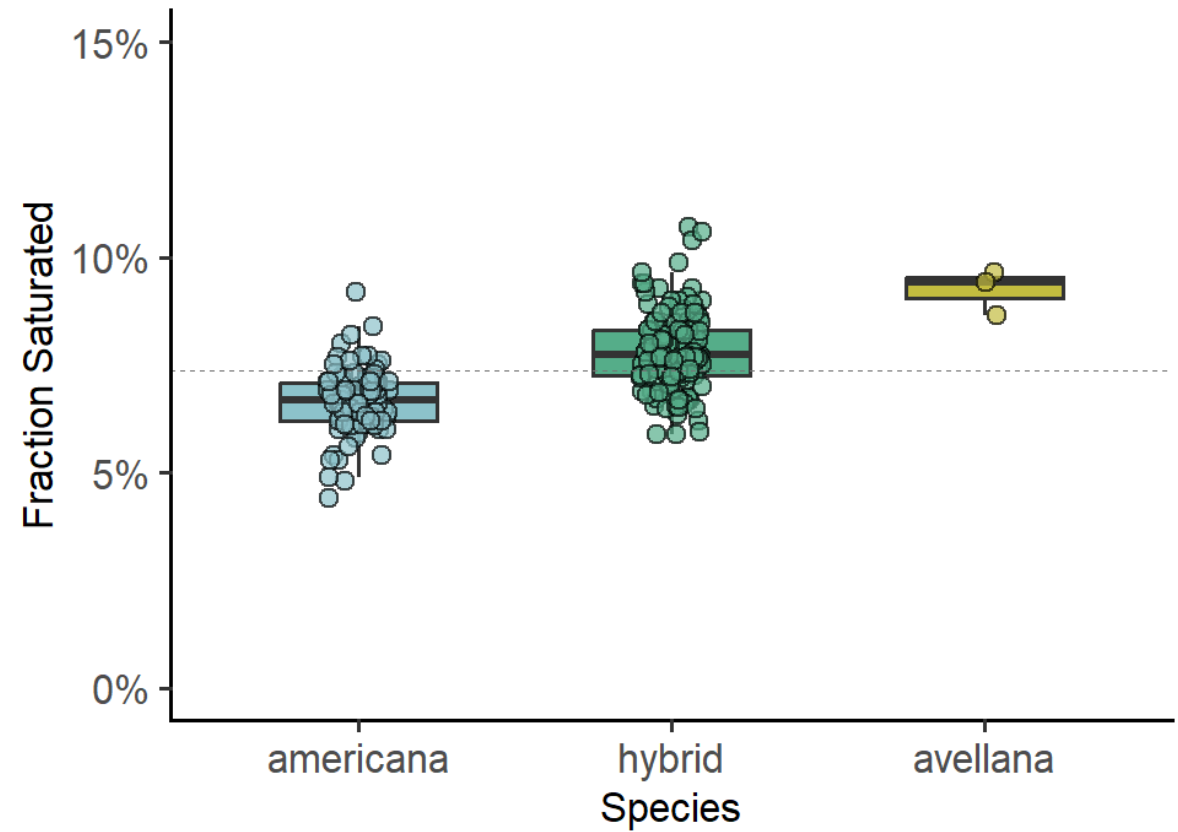
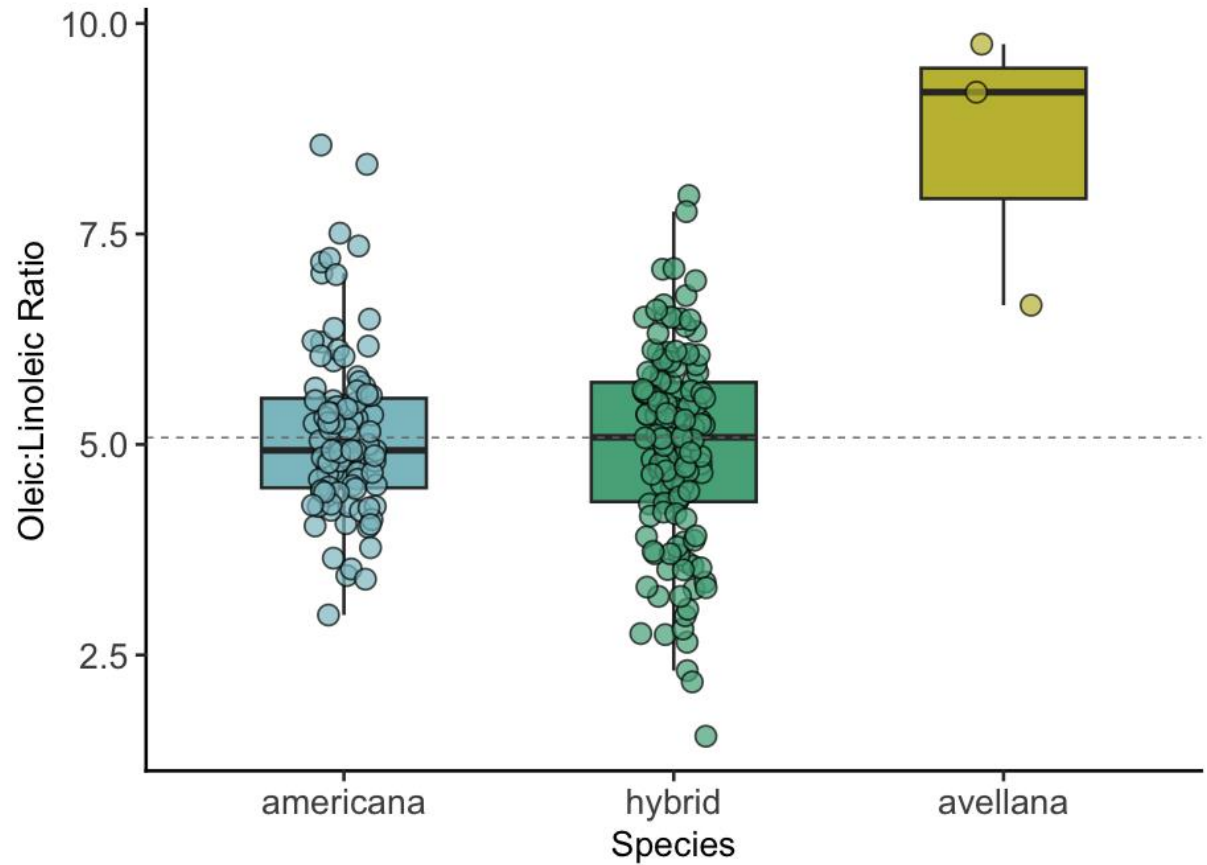


Hazelnut oil is high in oleic fatty acid and low in saturated fats

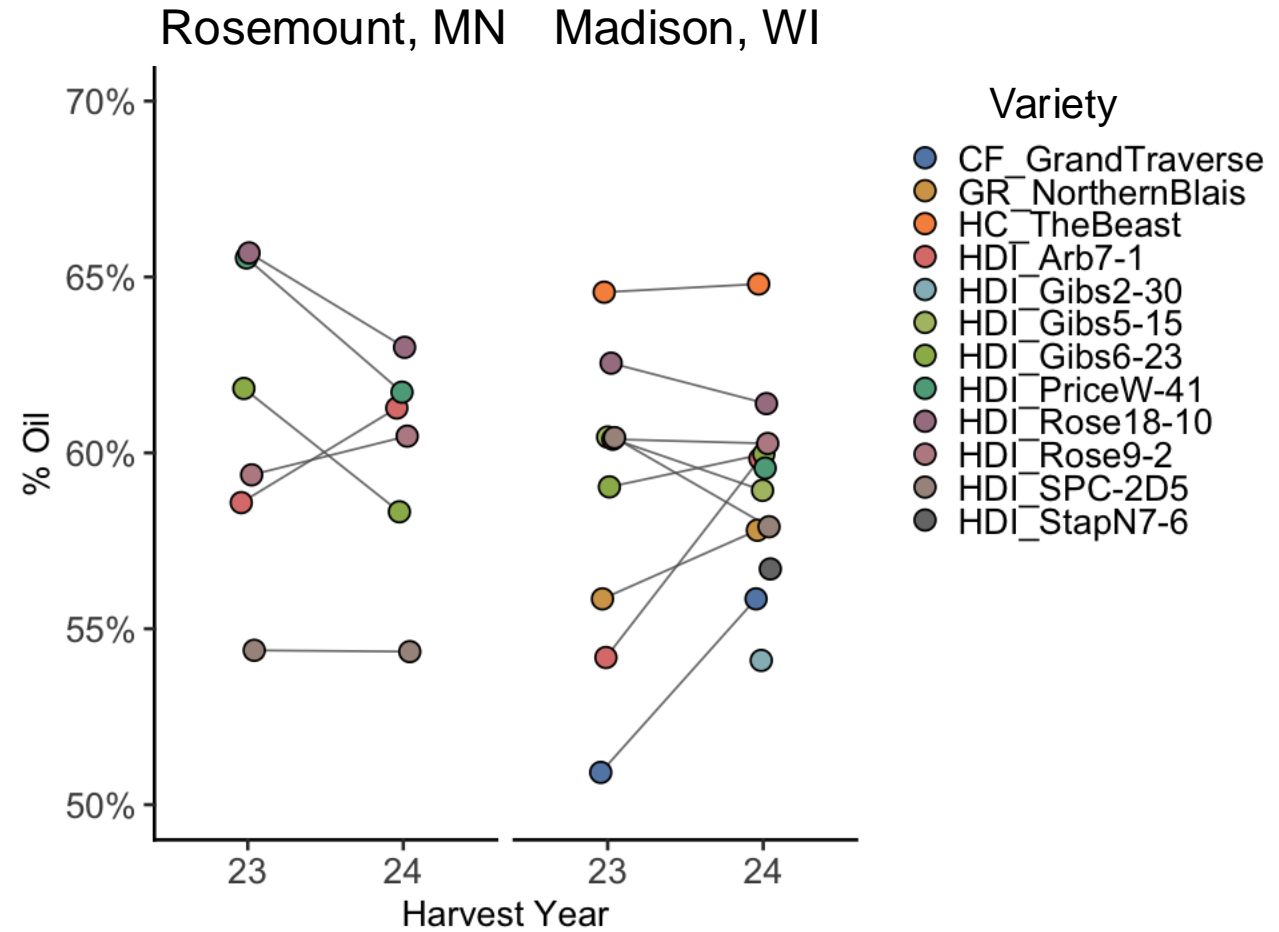
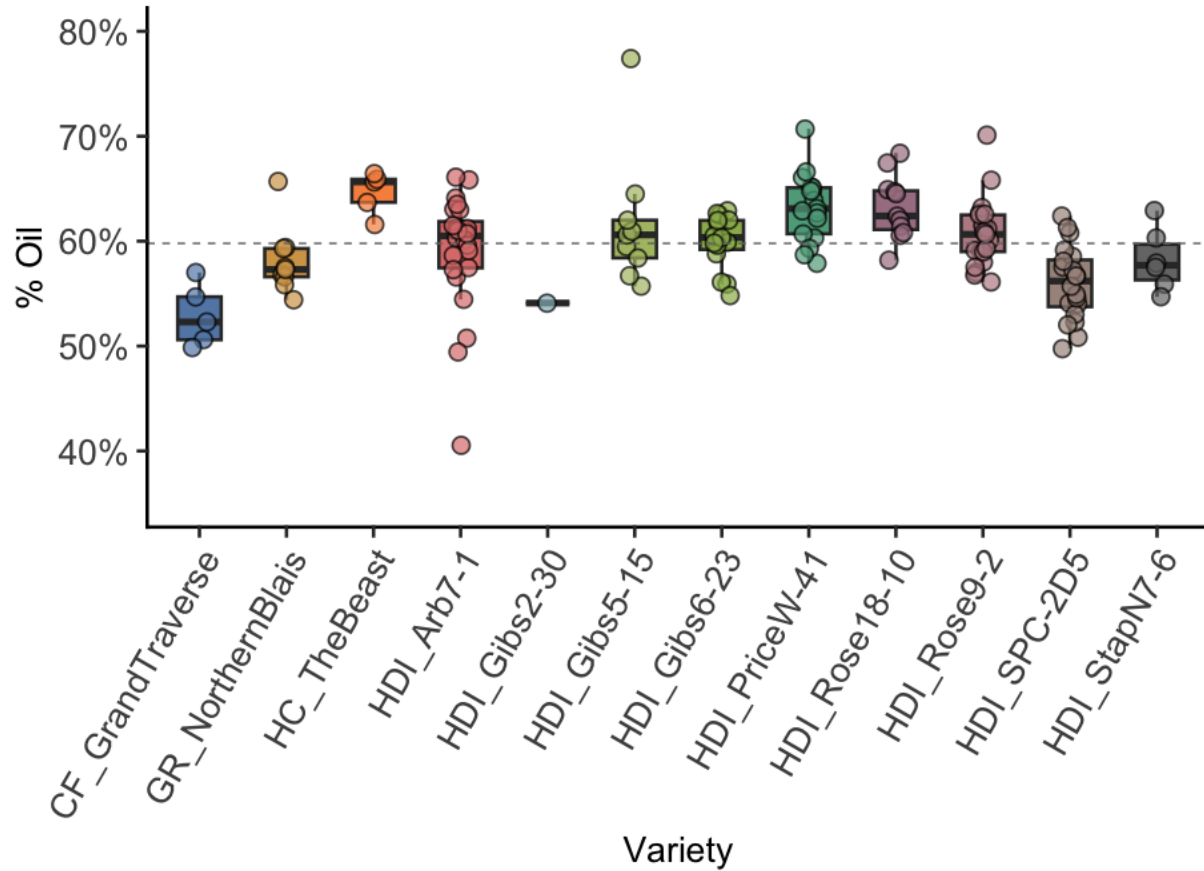
Oil Type	Monounsaturated		Polyunsaturated		Saturated	Higher = more stable oil Oleic:Linole(n)ic
	Oleic	Linoleic	Linolenic			
Hazelnut*	81.0	7.5	0	8.0	10.8	
Hybrid Hazelnut	78.1	16.1	0	7.8	4.8	
American Hazelnut	77.8	15.6	0	6.7	5.0	
High-oleic sunflower*	75.0	16.0	0	9.0	4.7	
Olive*	75.5	7.5	1.0	14.5	8.8	
Peanut*	41.0	35.5	0	17.5	1.2	
Walnut*	16.0	59.0	12.0	11.0	0.2	
Hickory	58.1	26.0	4.0	11.9	1.9	

* Values from Guillén, M. and Ruis, A. *Eur. J. Lipid Sci. Technol.* **2003**, *105*, 688-696.

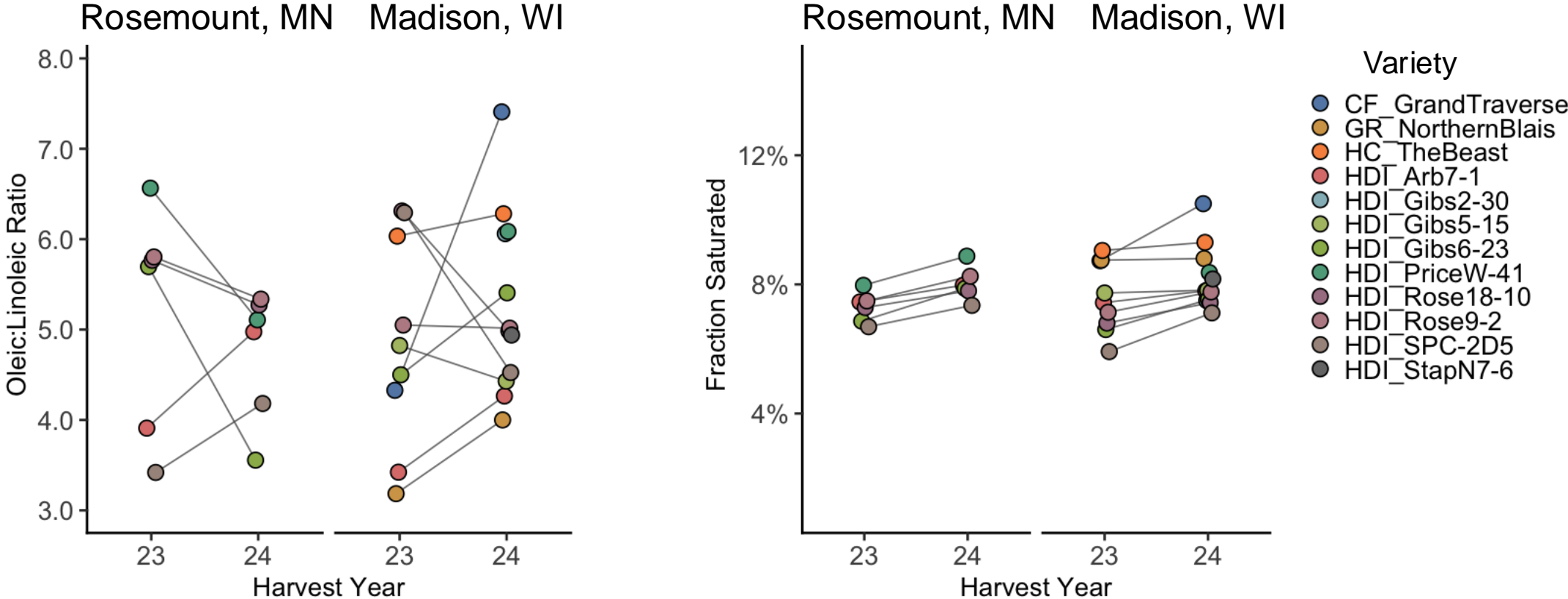
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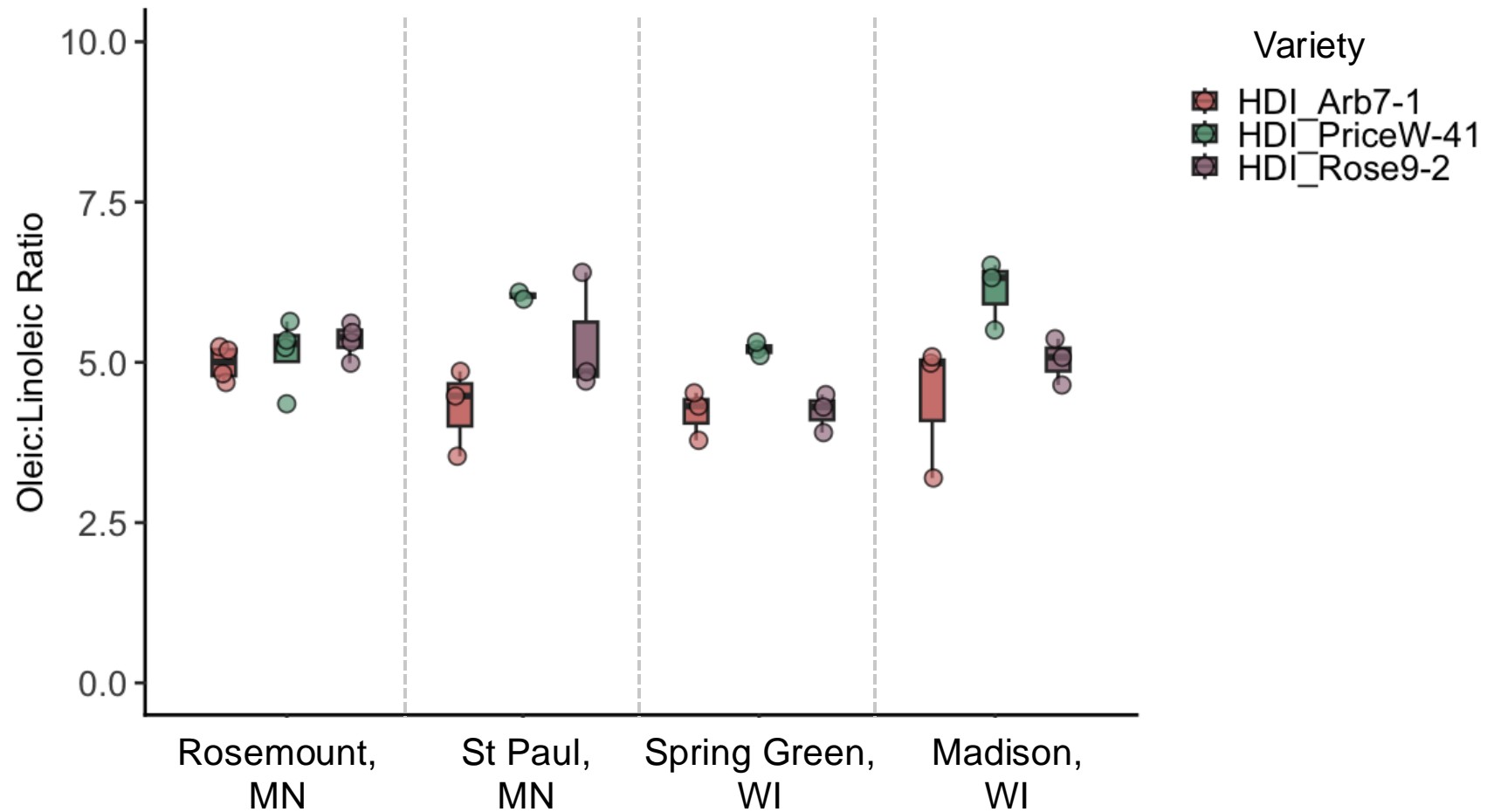
Oil composition varies within varieties across location and harvest year



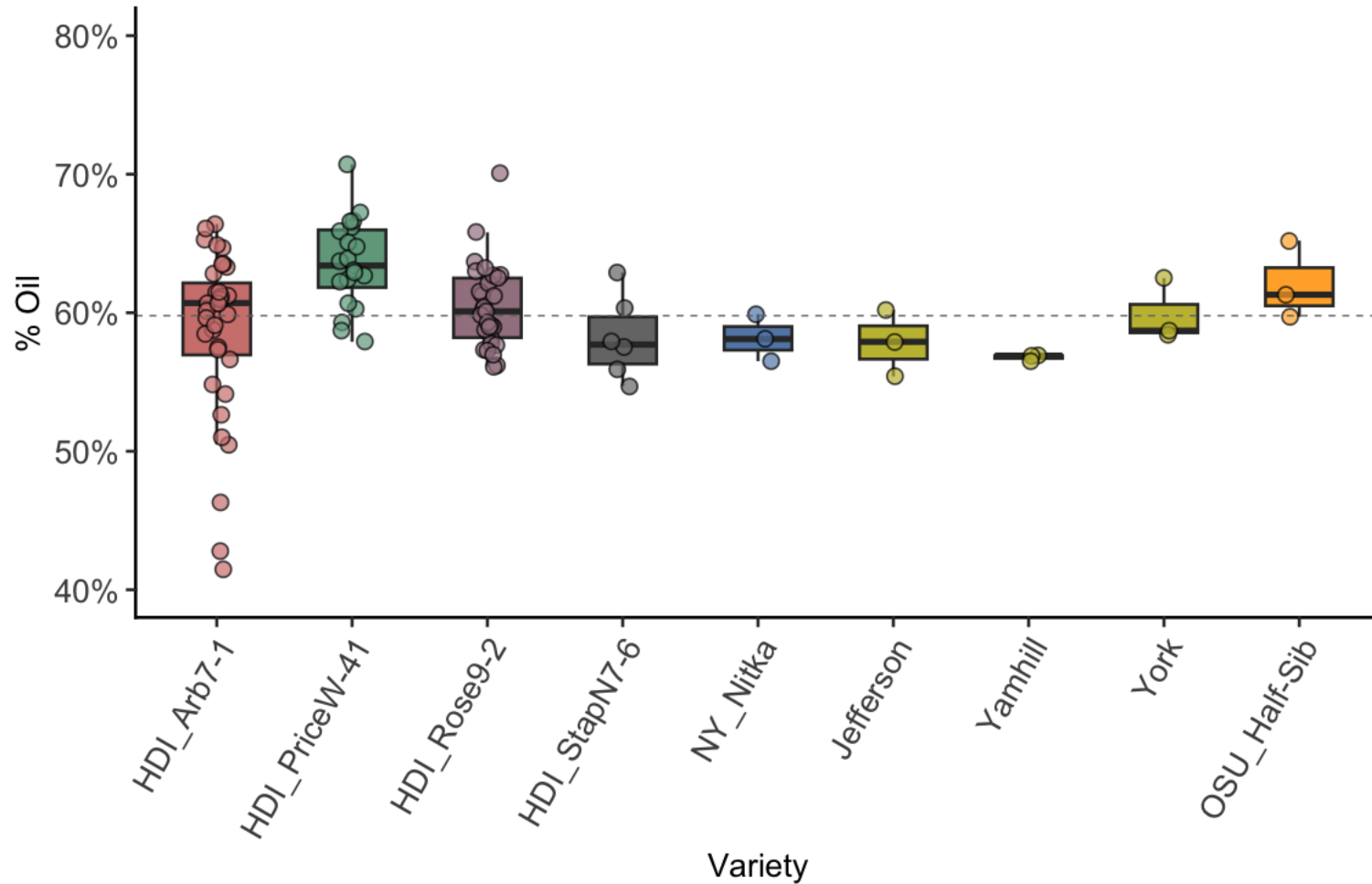
Saturated fatty acids are the most consistent across years



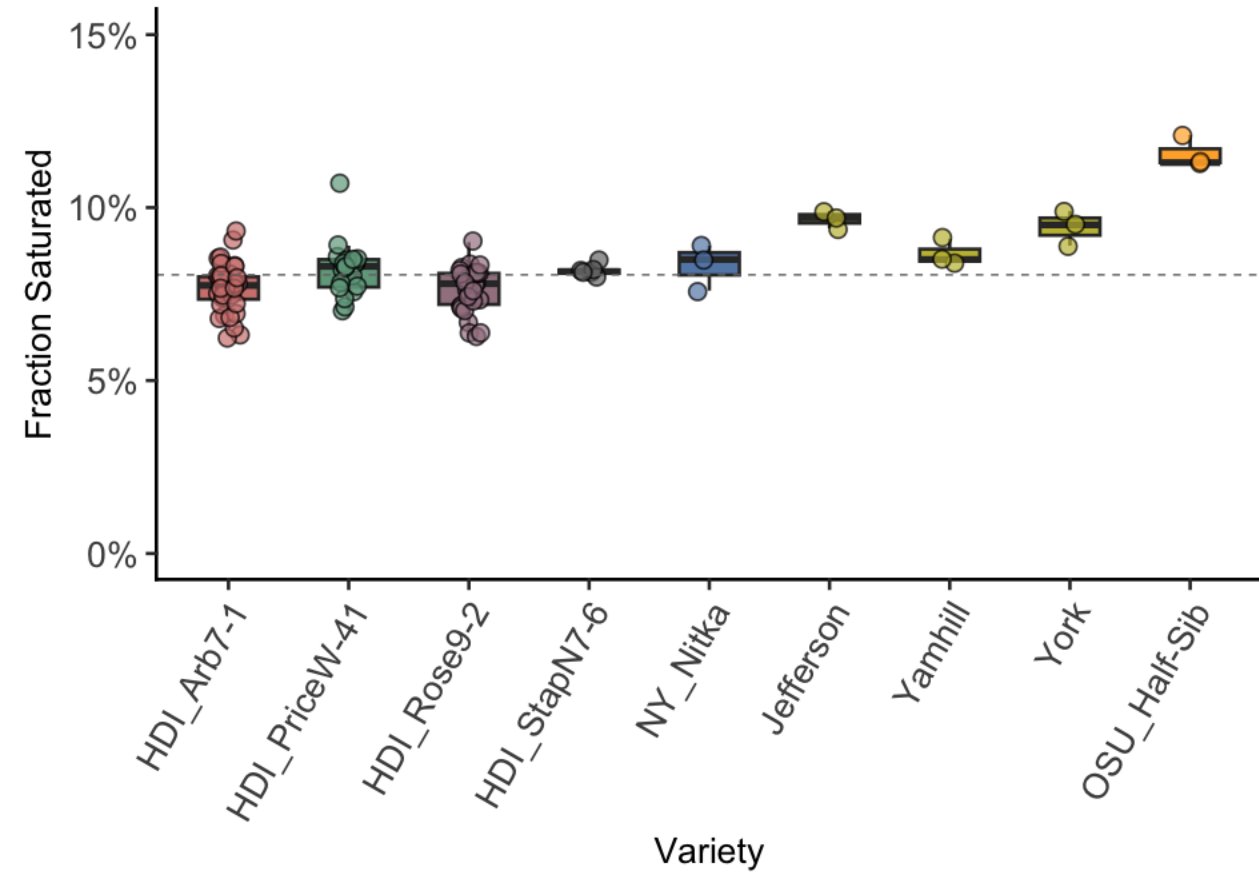
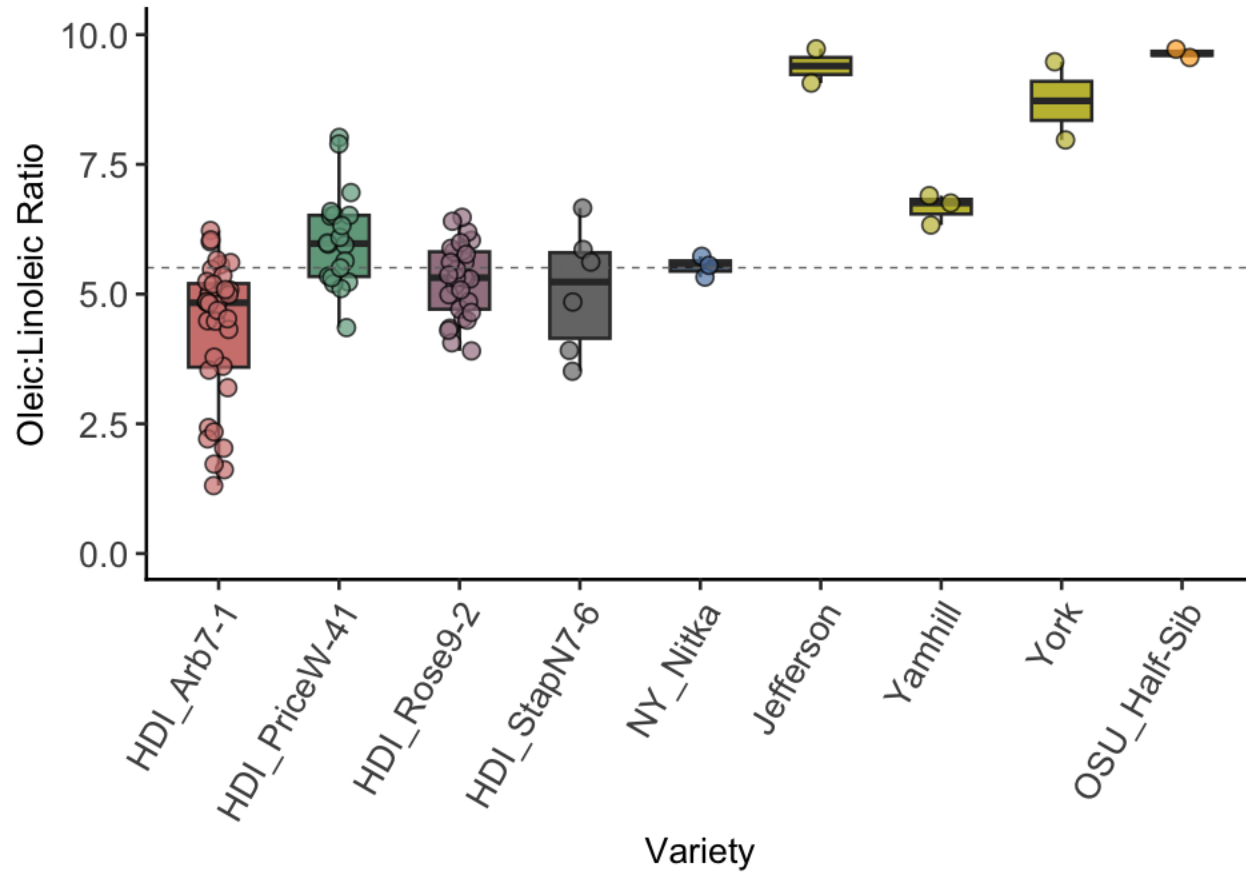
Oil composition varies within varieties across location and harvest year



How do top Midwest varieties compare to other regions?



How do top Midwest varieties compare to other regions?



Summary

- Midwest hazelnuts – both hybrids and *C. americana* – vary greatly in protein content and oil composition
- *C. americana* has higher average total oil content than hybrid plants
- Midwest hazelnuts currently have a lower oleic:linoleic acid ratio than European varieties – but higher than other nuts
- Near infrared (NIR) spectroscopy can be used for evaluating breeding populations

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